MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

EME1046 – PRINCIPLES OF THERMODYNAMICS
(ME)

22 OCTOBER 2018
9.00 a.m –11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 printed pages (including cover page and appendix) with four questions.
2. Attempt **ALL FOUR** questions. Each question carries 25 marks.
3. Please write all your answers in the Answer Booklet provided.
4. All necessary workings must be shown.
5. A property tables booklet is provided.

Question 1

a) Determine the absolute pressure P_1 of the manometer shown in Figure 1 in kPa. The local atmospheric pressure is 760 mmHg. Fluid A is water and Fluid B have a specific gravity of 0.8.
(Density of water = 1000 kg/m^3; g = 9.81 m/s^2) [5 marks]

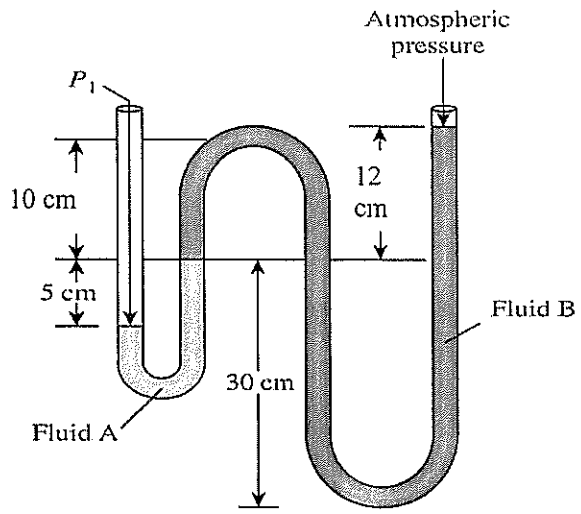

Figure 1

b) The water behind a dam is 200 m higher than the river below it. Determine at what rate the water must pass through the hydraulic turbines of this dam to produce 100 MW of power if the turbines are 100 percent efficient. [3 marks]

c) A piston-cylinder device contains 0.8 m^3 of saturated water vapor having a quality of 0.6 at 120 °C (State 1). Heat is then transferred to the saturated water vapor at constant pressure until the temperature reaches 200 °C (State 2).
 i) Determine the initial pressure of the saturated water vapor. [1 mark]
 ii) Determine the total mass of the saturated water vapor. [3 marks]
 iii) Determine the volume change due to the heat transferred. [4 marks]
 iv) Determine the amount of energy transferred to the saturated water vapor. [4 marks]
 v) The water at State 2 is then compressed isothermally until all the water condensed (State 3). Sketch the two processes on a *T-v* diagram with respect to the saturated liquid and saturated vapor lines. Label all the states and the paths. Use arrow to indicate the direction of each process. [5 marks]

Continued ...

Question 2

a) A gas is compressed adiabatically with a volume compression ratio of 3. The initial temperature is 25 °C and pressure is at 15 kPa. Given the index of compression, n = 1.5, find

i) the final temperature (in °C), [2 marks]

ii) the final pressure (in kPa). [4 marks]

b) Refrigerant-134a at 600 kPa and 150 °C is contained in a spring-loaded piston-cylinder device with an initial volume of 0.4 m^3. The refrigerant is now cooled until its temperature is -30 °C and its volume is 0.2 m^3.

i) Find the specific volume and specific internal energy at the initial state and the final state. [9 marks]

ii) Show the process in *P-v* diagram. [3 marks]

iii) Determine the work produced by the refrigerant during this process. [3 marks]

iv) Determine the heat transferred to the refrigerant during this process. [4 marks]

Question 3

a) A gas refrigeration system operating on R-134a has an adiabatic and reversible compressor, a heat exchanger, an adiabatic and reversible turbo-expander (turbine) and a second heat exchanger. State data are provided in the Table 1 below.

Table 1

State	P (bar)	T (°C)
1	1	10
2	7	
3	7	40
4	1	

The given pressure is absolute.

i) Sketch a schematic diagram of the refrigeration system and indicate all states in your diagram. [4 marks]

ii) Determine the specific work associated with the compressor in kJ/kg. [5 marks]

iii) Determine the heat transfer from the higher temperature heat exchanger in kJ/kg. [3 marks]

iv) Determine the temperature at state 4. [3 marks]

v) Sketch the processes on a T-s diagram. [4 marks]

vi) State any assumptions you made in your calculation above. [2 marks]

b) Determine the rate of heat rejection from a reversible heat engine operating between a hot reservoir at 900 K and a cold reservoir at 400 K if the engine produces a power output of 400 kW. [4 marks]

Continued ...

Question 4

a) An electrically heated system showed in **Figure 2** is used for an industrial application where both vapor and liquid streams are needed for different processes. The system operates at steady state and consumes electricity at the rate of 350 kW. Liquid water enters at 1.5 bar and 70 °C (State 1), while 0.1 kg/s of superheated water vapor exits at 1.5 bar and 200 °C (State 2) and 0.3 kg/s of saturated liquid water exits at 1.5 bar (State 3). The outside surface of the system has heat transfer to its local environment whose temperature is 20°C.
The given pressure is absolute.

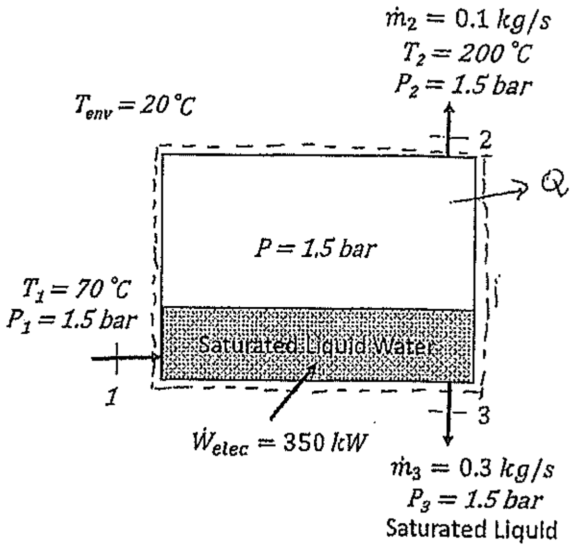

Figure 2

Table 2

State	P (bar)	T (°C)	h (kJ/kg)	s (kJ/kg.K)
1	1.5	70		
2	1.5	200		
3	1.5			

i) Complete the properties in the table at each of the state points. [7 marks]

ii) Determine the rate and direction of heat transfer (kW) between the system and the environment. [5 marks]

iii) Calculate the total rate of entropy generation (kW/K). [4 marks]

iv) If an external heat transfer of 350 kW from a source at 1000°C were to be used instead of electrical heating power of 350 kW, then comment on whether the total rate of entropy generation would increase, decrease, or remain the same. Justify your answer with a basic equation. [4 marks]

b) Consider the following devices.
Device 1: A refrigerator that, without any work being done, transfers in each cycle of operation, 500 J from a system at 200 K to the surroundings at 280 K.
Device 2: An engine that in each cycle of operation receives 1000 J from a high temperature reservoir at 500 K and supplies the 1000 J to do useful work.
Calculate the entropy changes involved in each for these devices and indicate which devices, if any, cannot operate. [5 marks]

Continued ...

Appendix

Uniform State Uniform Flow (Unsteady Flow)

Continuity:

$$(m_2 - m_1) = \sum_i m_i - \sum_e m_e$$

First Law:

$$Q_i + W_i + \sum_i m_i\left(h_i + \frac{V_i^2}{2} + gZ_i\right) - Q_e - W_e - \sum_e m_e\left(h_e + \frac{V_e^2}{2} + gZ_e\right)$$
$$= m_2\left(u_2 + \frac{V_2^2}{2} + gZ_2\right) - m_1\left(u_1 + \frac{V_1^2}{2} + gZ_1\right)$$

Second Law:

$$m_2 s_2 - m_1 s_1 = \sum_i m_i s_i - \sum_e m_e s_e + \int_0^t \frac{\dot{Q}_{cv}}{T} dt + {}_1S_{2\,gen}$$

Ideal Gas

Ideal Gas Equations of State

$$Pv = RT$$
$$dh = C_p dT$$
$$du = C_v dT$$

Specific Heats and Ideal Gas Constants

$$C_p - C_v = R$$
$$\frac{C_p}{C_v} = k$$

Entropy Relationships

$$\begin{aligned} s_2 - s_1 &= C_v \ln\frac{T_2}{T_1} + R\ln\frac{v_2}{v_1} \quad \text{if constant } C_v \\ &= C_p \ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1} \quad \text{if constant } C_p \\ &= s^0_{T_2} - s^0_{T_1} - R\ln\frac{P_2}{P_1} \quad \text{otherwise} \end{aligned}$$

For polytropic process

$$PV^n = c$$

$$\begin{aligned} {}_1W_2 &= \frac{P_2V_2 - P_1V_1}{1-n} \quad n \neq 1 \\ &= P_1V_1 \ln\frac{V_2}{V_1} \quad n = 1 \end{aligned}$$

End of Paper.